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EP-A-0 022 235  
FR-A-2 148 085  
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FR-A-2 538 526  
GB-A- 310 819  
US-A-3 689 972

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## Description

This invention relates to a heat exchanger comprising spaced generally parallel header and tank manifolds each of which has elongated spaced tube receiving holes in a header surface thereof, the holes in one header surface being aligned with and facing corresponding holes in the other header surface, elongated open ended flattened tubes extending between and into the header and tank manifolds through aligned ones of the holes, and the portion of each header surface between adjacent holes being formed as an exteriorly convex protrusion.

Such a heat exchanger is disclosed in FR-A-2 538 526. Each of its manifolds is fashioned with a tube end plate in which the tube receiving holes are formed and which is covered by a water box. At its periphery, the tube end plate is shaped to define a groove receiving a deformable gasket which is squeezed in the bottom of the groove by an edge of the water box. The exteriorly convex protrusions are fashioned in the tube end plate as transverse slots between adjacent rows of tube receiving holes. Such slots serve the purpose that they can be subjected to deformations due to differential heat expansions between the tubes without these deformations being transmitted to the groove resulting in stressing of the gasket therein; rather, the peripheral groove is made rigid by the rounded ends of the slots. Therefore, the transverse slots are provided so that the tube end plate will flex to accommodate thermally-caused deformations between adjacent tubes.

In manufacturing heat exchangers of this type, holes must be formed in the header surfaces of each of the header and tank manifolds to receive the ends of the tubes. Most frequently this is accomplished by a punching operation wherein material is actually removed from the header surface at the hole location, but even where the hole is formed simply by piercing and deformation without material removal, the resulting lack of continuity in the header surface weakens the same.

Those skilled in the art will readily recognize that heat exchangers of the sort of concern are pressurized, that is, the heat exchange fluid within the tubes and the header and tank manifolds will be subjected to an elevated pressure. Because the header surface in the area of the holes is weakened during the formation of the holes, such elevated pressure may cause deformation in those areas. The deformation, in turn, can result in the formation of leakage openings at the joints between the tubes and the header surface. If the elevated pressure becomes extreme, rupture of the header surface can also occur.

It is therefore the object of the invention to provide increased resistance to deformation as a result of force exerted by a pressurized fluid within the header and tank manifolds.

In accordance with the invention this object is solved, in that each exteriorly convex protrusion

is a dome having a compound curve configuration.

Contrary, therefore, to the structure of FR-A-2 538 526 of which the principal object of the transverse channels is to enable the header surfaces to flex to accommodate thermally-caused deformations so that such deformations are not transmitted to the margin of the manifold to the detriment of the sealing gasket therein, the heat exchanger of the present invention provides, by its domes having a compound curve configuration, a multitude of localized strengthened zones in the header surface between adjacent tube holes capable of resisting the force of the pressurized fluid which would otherwise deform the header surface weakened by the formation of the tube holes and, in so doing, tend to cause leakage at the joints between the tubes and the header surface and even possibly rupture of the header surface.

Preferably, the compound curvature of the domes is that of a nominal sphere in which case mathematical analysis has illustrated that the domes at least double the strength of the header surfaces between the holes were they left to have a cylindrical or planar configuration. Such a configuration is particularly advantageous where the header and tank manifolds comprise tubes of generally circular cross-section and the flattened tubes are arranged side-by-side in a single row extending between the manifold circular tubes and with the major cross-sectional dimension of each flattened tube transverse to the lengths of the circular tubes since, by suitably spacing apart the flattened tubes lengthwise of the manifold circular tubes, the curvature of each strengthening dome considered circumferentially of the manifold tube may be that of the circumferential periphery of the manifold tube itself.

The header and tank manifolds may each be an integral or one-piece element or may be defined by a header plate and a separate tank secured to and sealed against the header plate with, preferably, a gasket interposed between the tank and header plate.

In order that the invention may be well understood there will now be described two embodiments thereof, given by way of example with reference to the accompanying drawings, in which:

Fig. 1 is a perspective view of a heat exchanger embodying the invention;

Fig. 2 is an enlarged, fragmentary sectional view taken approximately along the line 2-2 of Fig. 1;

Fig. 3 is a sectional view taken approximately along the line 3-3 of Fig. 2;

Fig. 4 is a further sectional view taken approximately along the line 4-4 of Fig. 2; and

Fig. 5 is an enlarged, fragmentary sectional view of an alternative embodiment of the invention.

Referring first to Fig. 1, a heat exchanger includes an upper header and tank manifold, generally designated 10, and a spaced, generally

parallel lower header and tank manifold, generally designated 12. A single row of elongated, open ended oval or flattened tubes 14, in spaced, generally parallel, side-by-side relation extend between the header and tank manifolds 10 and 12. Platelike or serpentine fins (not shown) may be disposed between the header and tank manifolds 10 and 12 and in heat exchange relation with the tubes 14 in a conventional fashion as desired.

In the embodiment illustrated in Figs. 1-4, each of the header and tank manifolds 10 and 12 is formed of an integral or one-piece element, namely, an elongated tube 16 of generally circular cross section. Suitable ports (not shown) are in fluid communication with the interior of each of the tubes 16.

The facing surfaces of the tubes 16 defining the upper and lower header and tank manifolds 10 and 12 are indicated generally at 18 and are the header surfaces of each header and tank manifold.

As seen in Figs. 2 and 3, the header surfaces 18 are provided with a series of spaced, generally parallel, elongated holes 20 which receive the open ends 22 of the flattened tubes 14 so that the major cross-sectional dimension of each tube 14 is transverse to the longitudinal axes of the manifold tubes 16. The tubes 14 will be sealed to the respective header and tank manifold 10 or 12 within the holes 20 by any suitable means as well as bonded thereto sufficiently so as to provide structural integrity. Where metal components are used, solder or braze metal will conventionally be employed for the purpose.

The header surfaces 18, between the holes 20, are formed as exteriorly convex domes 24 which have a compound curve configuration, that is, have a curved appearance both circumferentially of the header and tank manifolds 10 and 12 (see Fig. 4) and axially of the length of the header and tank manifolds 10 and 12 (see Fig. 2). In a highly preferred embodiment, the domed configuration will nominally be that of a portion of a sphere having the same circumference as the respective manifold tube, as shown in Figs. 3 and 4.

Depending upon the material of which the header and tank manifold 10 and 12 is formed, the domes 24 may be provided in the surfaces 18 by stamping, molding or the like.

Fig. 5 shows an alternative embodiment of the invention. The flattened tubes are shown at 14 as in Figs. 1-4 whereas an upper header and tank manifold is shown generally at 40. In the case of the embodiment of Fig. 5, the header and tank embodiment 40 is formed of a number of components including a header plate 42 and a tank 44 of metal or plastic. The tank 44 has an open side at 46 and is surrounded by an outwardly directed peripheral flange 48. The header plate 42 has an upturned peripheral flange 50. The tank 44 is placed within the flange 50 against a compressible gasket or O-ring 52 which is compressed until sealing contact between both the tank 44 and the

header plate 42 is obtained. A series of fingers 54 are deformed from the header plate flange 50 toward the tank 44 to overlie and retain the flange 46 in any of a variety of ways known in the art.

The header plate 42 includes spaced, generally parallel, elongated openings 56 which receive the open ends 22 of the tubes 14. Again, the tubes 14 are sealed and bonded to the header plate 42 at the opening 56. Exteriorly convex domes 58 of the same general configuration as the domes 24 are disposed in the header plate 42 between the holes 56.

#### Claims

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1. A heat exchanger comprising spaced generally parallel header and tank manifolds (10, 12; 40) each of which has longitudinally spaced tube receiving holes (20; 56) in a header surface (18; 42) thereof, the holes in one header surface being aligned with and facing corresponding holes in the other header surface, open ended flattened tubes (14) extending between and into the header and tank manifolds through adjacent ones of the holes; and the portion of each header surface between adjacent holes being formed as an exteriorly convex protrusion (24; 58), characterized in that each exteriorly convex protrusion is a dome (24; 58) having a compound curve configuration.

2. A heat exchanger as claimed in Claim 1, wherein the compound curve configuration is that of a nominal sphere.

3. A heat exchanger as claimed in Claim 1 or Claim 2, wherein each header and tank manifold (10, 12) is a tube (16) with a curved header surface (18), the flattened tubes (14) are arranged side-by-side in a single row with adjacent flattened tubes spaced apart in the direction of the longitudinal axis of each manifold tube and with the major cross-sectional dimension of each flattened tube transverse to that longitudinal axis, and the curve of each dome considered in a direction circumferentially of the respective manifold tube is that of the curved header surface thereof.

4. A heat exchanger as claimed in Claim 3, wherein each manifold tube (16) is of generally circular cross-section.

5. A heat exchanger as claimed in any of the preceding Claims, wherein each header and tank manifold (10, 12) is a one-piece or integral element (16).

6. A heat exchanger as claimed in Claim 1 or Claim 2, wherein each header and tank manifold (40) is defined by a header plate (42) and a separate tank (44) secured to and sealed against the header plate, the header plate defining the header surface (42).

7. A heat exchanger as claimed in Claim 5, wherein the tank (44) is open sided, and including a gasket (52) interposed between and sealing the header plate (42) to the tank around the open side thereof.

## Patentansprüche

1. Wärmetauscher mit voneinander beabstandeten, im wesentlichen parallel zueinander verlaufenden Sammel- und Aufnahmeverteilern (10, 12; 40), von denen jeder in einer Kopfstückfläche (18; 42) in Längsrichtung voneinander beabstandete Rohraufnahmöffnungen (20; 56) aufweist, wobei die Öffnungen in der einen Kopfstückfläche mit denen in der anderen Kopfstückfläche in Ausrichtung stehen und diese gegenüberliegen, wobei sich offenendige abgeflachte Rohre (14) zwischen den Sammel- und Aufnahmeverteilern und durch jeweils benachbarte der vorhandenen Löcher in die Sammel- und Aufnahmeverteiler hinein erstrecken, und wobei der zwischen benachbarten Öffnungen gelegene Abschnitt jeder Kopfstückfläche als ein äußerer konvexer Vorsprung (24; 58) ausgebildet ist, dadurch gekennzeichnet, daß jeder der äußeren konvexen Vorsprünge als eine Kuppel (24; 58) mit zusammengesetzten kurvenlinienförmiger Gestalt ausgebildet ist.

2. Wärmetauscher nach Anspruch 1, bei dem die zusammengesetzte kurvenlinienförmige Gestalt die einer Nennkugel ist.

3. Wärmetauscher nach Anspruch 1 oder 2, bei dem jeder Sammel- und Aufnahmeverteiler (10, 20) eine Rohr (16) mit einer gekrümmten Kopfstückfläche (18) ist, wobei die abgeflachten Rohre (14) Seite an Seite in einer einzigen Reihe angeordnet sind, wobei benachbarte abgeflachte Rohre in Richtung der Längsachse jedes Verteilerrohres voneinander beabstandet sind, wobei das größere Querschnittsmaß jeder abgeflachten Röhre quer zu dieser Längsachse verläuft, und wobei die Krümmungslinie jeder Kuppel, in Umfangsrichtung des jeweiligen Verteilerrohres gesehen, die der gekrümmten Kopfstückfläche desselben ist.

4. Wärmetauscher nach Anspruch 3, worin jedes Verteilerrohr (16) einem im wesentlichen kreisförmigen Querschnitt aufweist.

5. Wärmetauscher nach einem der vorhergehenden Ansprüche, bei dem jeder Sammel- und Aufnahmeverteiler (10, 12) ein einstückiges oder einheitliches Element (16) ist.

6. Wärmetauscher nach Anspruch 1 oder 2, bei dem jeder Sammel- und Aufnahmeverteiler (40) durch eine Kopfplatte (42) und einen getrennten Behälter (44) umgrenzt ist, der an der Kopfplatte befestigt und mit dieser dichtend in Verbindung steht, wobei die Kopfplatte die Kopfstückfläche (42) umgrenzt.

7. Wärmetauscher nach Anspruch 5, bei dem der Behälter (44) an einer Seite offen ist, und bei dem eine Dichtung (52) zwischen der Kopfplatte (42) und um die offene Seite des Behälters angeordnet ist und diese gegeneinander abdichtet.

## Revendications

1. Echangeur de chaleur comprenant des collecteurs distants et parallèles de façon générale d'entrée et de sortie (10, 12; 40) ayant chacun des trous (20; 56) de logement de tubes qui sont espacés longitudinalement dans une surface de collecteur (18; 42), les trous d'une première surface de collecteur étant alignés sur les trous correspondants de l'autre surface de collecteur et étant tournés vers eux, des tubes aplatis (14) ayant des extrémités ouvertes étant placés entre les collecteurs et pénétrant dans ces collecteurs par des trous adjacents, la partie de chaque surface collectrice comprise entre des trous adjacents ayant la forme d'une saillie convexe vers l'extérieur (24; 58), caractérisé en ce que chaque saillie convexe vers l'extérieur est un dôme (24; 58) ayant une configuration de courbure composite.

2. Echangeur de chaleur selon la revendication 1, dans lequel la configuration de courbure composite est celle d'une sphère nominale.

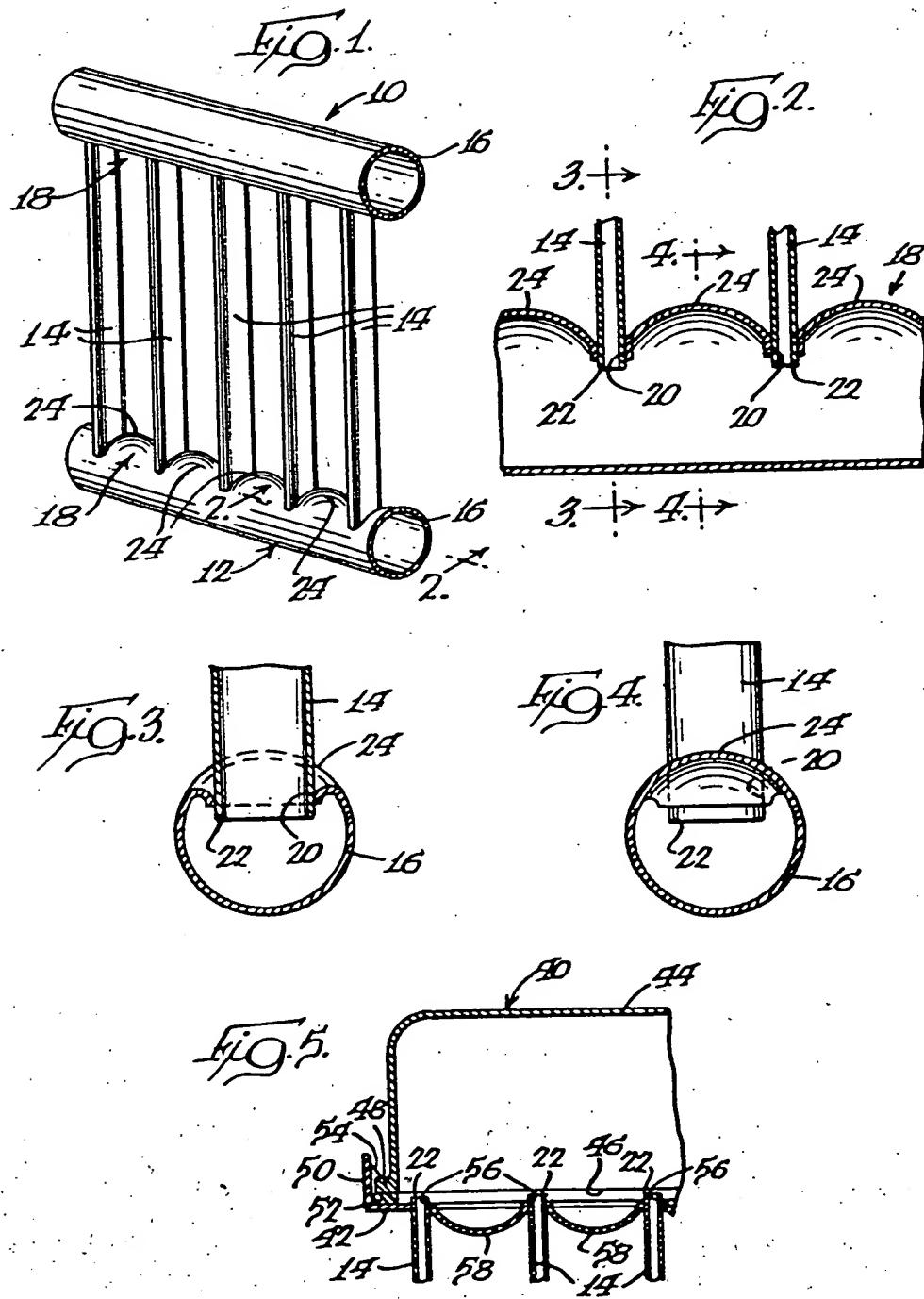
3. Echangeur de chaleur selon la revendication 1 ou 2, dans lequel chaque collecteur d'entrée et de sortie (10, 12) est un tube (16) ayant une surface courbe (18) de collecteur, les tubes aplatis (14) sont placés côté à côté sous forme d'une seule ligne, les tubes aplatis adjacents étant séparés suivant l'axe longitudinal de chaque tube collecteur, la plus grande dimension en coupe de chaque tube aplati étant transversale à l'axe longitudinal, et la courbe de chaque dôme, considérée dans la direction circonférentielle du tube collecteur respectif, est celle de la surface courbe du collecteur.

4. Echangeur de chaleur selon la revendication 3, dans lequel chaque tube collecteur (16) a une section de forme générale circulaire.

5. Echangeur de chaleur selon l'une quelconque des revendications précédentes, dans lequel chaque collecteur d'entrée et de sortie (10, 12) est un élément en une seule pièce ou solidaire (16).

6. Echangeur de chaleur selon la revendication 1 ou 2, dans lequel chaque collecteur d'entrée et de sortie (40) est délimité par une plaque (42) et un réservoir séparé (44) fixé à la plaque et coopérant de façon étanche avec celle-ci, la plaque délimitant la surface collectrice (42).

7. Echangeur de chaleur selon la revendication 5, dans lequel le réservoir (44) est ouvert sur le côté, et comprenant une garniture (52) placée entre la plaque collectrice (42) et le réservoir autour de son extrémité ouverte afin qu'elle assure l'étanchéité.



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